Protecting Workers from Toxic Fumes Generated by Explosives

By Richard Mainiero

In any construction project involving explosives, care must be taken to protect workers from carbon monoxide (CO) generated by blasting operations.

CO is an odorless, colorless gas that can cause illness and death by asphyxiation. In general, the first symptoms include headache, fatigue and lightheadedness. At higher exposures to CO, skin flushing, rapid heart rate, and lowered blood pressure occur. At even higher exposure levels, decreased attention span is followed by nausea, vomiting, impaired coordination, fainting, coma, convulsions and, finally, death.

The detonation of explosives in blasting operations generates a range of toxic fumes, but CO is the most insidious because it is colorless, odorless, and is long lasting, since it is not readily removed by reaction with ground water, soil or rock.

Additionally, CO is generated in relatively large quantities compared to other toxic fumes. CO may continue to seep out of blasted material long after the odor commonly associated with detonated explosives has dissipated. It is never safe to assume a confined space in the vicinity of a blast is clear of toxic fumes. CO may be present even if the area looks clear and many hours have passed since the last blast.

In a 1997 incident, three cases of CO poisoning in a confined space, including one fatality, were caused by CO migrating through soil after nearby use of explosives. A NIOSH Hazard Alert described the incident as follows:

"A municipal sewer project involved the installation of new pipes and manholes. Explosive blasts were used to break up rock layers 6 feet below the surface before excavating pipeline trenches and manhole pits. On the day of the fatality, a construction crew installed a 12-foot-deep manhole without incident. After the crew left the area, 265 pounds of nitroglycerin-based explosive in 20 boreholes, each 18 feet deep, were detonated 40-60 feet from the manhole. A worker who entered the manhole 45 minutes after the explosion collapsed within minutes, and two coworkers descended into the manhole to rescue him. One rescuer retrieved the unconscious worker before collapsing on the surface, and the other rescuer died in the manhole. All involved construction workers had elevated blood levels of carboxyhemoglobin indicating they had inhaled air containing high CO concentrations.

"An investigation determined that carbon monoxide released from the explosion had migrated through the soil into the manhole. CO concentrations in the bottom of the manhole two days after the incident were 1,905 parts per million (ppm), well above the immediately dangerous to life and health (IDLH) concentration of 1,200 ppm. Tests following ventilation of the manhole showed that high levels of CO reappeared as a result of continued diffusion from the surrounding soil. Subsequent monitoring of the manhole showed a decline in CO levels over the next eight days.

"This incident illustrates that CO from subsurface detonations of explosives can migrate underground and accumulate in confined spaces. This report is apparently the first occupational fatality from this type of CO exposure, though nonfatal CO poisonings have been reported in residential basements following nearby use of subsurface explosives."

Ongoing NIOSH research at the Pittsburgh Research Lab has shown that the quantity of CO and other toxic fumes generated in blasting operations can vary significantly depending on the type of explosive employed and any carbonaceous materials that may be in the borehole with the explosive.

Ammonium nitrate-fuel oil (ANFO) blasting agents produce increased quantities of CO if its fuel oil content is too high. High explosives are typically formulated with a balance of fuel and oxidizer that minimizes the production of CO and other toxic gases. Any combustible material, such as cardboard sleeving, that is placed in the borehole with the explosive will act as fuel, upsetting the balance of fuel to oxidizer intended by the manufacturer, leading to excessive CO production. The best way to minimize toxic fume production is to ensure that explosives are used in the manner recommended by the manufacturer. Any confined space should be assumed to contain a toxic atmosphere until testing with proper instrumentation demonstrates otherwise.

Any combustible material, such as cardboard sleeving, that is placed in the borehole with the explosive will act as fuel, upsetting the balance of fuel to oxidizer intended by the manufacturer, leading to excessive CO production.

For information about carbon monoxide generation by explosives, call Richard Mainiero at the National Institute for Occupational Safety and Health (NIOSH), Pittsburgh Research Laboratory at (412) 386-6625. To obtain more free information about the hazard of confined spaces and procedures to protect workers call NIOSH at 1-800-35-NIOSH (1 800-356-4674), or visit the NIOSH home page on the World Wide Web at *http://www.cdc.gov/niosh/homepage.html*.

***Richard Mainiero** is a physical scientist for the National Institute for Occupational Safety and Health (NIOSH), Pittsburgh Research Center, Pittsburgh, Pa.*